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ABSTRACT

A study investigated to what extent adult native speakers of Mandarin Chinese learning English as a second language could pronounce the five front vowels of American English, how difficult this was, and which vowels were most difficult. Subjects were 16 Chinese university students and spouses and 16 American students. All subjects were recorded producing five words ("beat, bit, bait, bet, bat") in the sentence "I say------now." Production was digitized and the frequencies analyzed using a sound spectrograph. Results are presented separately for male and female subjects. They indicate that Chinese speakers were successful in producing native- or near-native-like frequencies for several phonemes and a diphthong. In the case of two phonemes, there was little difference between Chinese and native productions. Some conclusions were: among the five American English front vowels, /ey/ and /ae/ are the easiest ones for adult Mandarin Chinese speakers to pronounce; and /iy/ lies in the middle of the scale of difficulty. Contains 59 references. (MSE)

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English Learning: An Analysis of Chinese Students' Problems in Pronunciation

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Introduction

Experienced teachers of English as a second or foreign language know very well how important pronunciation is. However, it has been obvious for some time that little attention has been paid to the students' pronunciation in the process of second learning and teaching. According to Celce-Goodwin (1991), there have been different views over the past years about the value of teaching pronunciation in language teaching circles. They reported that teachers using grammar-translation reading-based methods and the cognitive approach attach no importance to pronunciation. In the direct approach, however, Celce-Murcia & Goodwin (1991) noticed, pronunciation is considered important. Leather (1985) reported that pronunciation is no longer considered as an indispensable element in second language teaching. The development of applied linguistics, especially the communicative approach has led people astray (Du, 1988).

However, there are not enough efforts to remedy the situation. "Most current textbooks in English as a second language (ESL) either ignore the teaching of pronunciation or rely primarily on old stand-bys -- to teach non-native learners to pronounce English accurately" (Beebe, 1984, p. 51).

Trammell (1993) also pointed out that instruction in pronunciation has been deemphasized due to the new teaching methods such as the Communicative and Acquisition Approaches. It seems that as long as one can communicate with people in the target language, everything is fine. But the question is, how can you communicate with people successfully if your pronunciation is incorrect?

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Some researchers like Scovel (1969, cited in Beebe, 1984) believe that native-like pronunciation in a second language is beyond attainment of those who have passed puberty. Beebe(1984) insists that pronunciation always affects what we communicate and how well we communicate it, and therefore it should be taken seriously. As Van Weeren & Theunissen (1987) pointed out:

> Firstly, good pronunciation allows one to be better understood. It gives the speaker's oral production a certain redundancy. and this can help to get a message across more effectively. Secondly, pronunciation is quite attractive as a learning objective because of its high payoff. The number of sounds, sound clusters, and intonation patterns in a language is finite, as is the alphabet. Once the system has been mastered, it can be used, thus giving it fundamentally an infinite scope. Thirdly, a deviant pronunciation means that one is immediately 'marked' as nonnative abroad. (p. 109)

Krashen (1981, 1985) has discussed the importance of comprehensible input. However, comprehensible output is equally important in the process of second language learning. That is one of the reasons why research needs to be done in the area of L2 production.

Background of the Problem

The question of pronunciation is so important that second language teachers cannot afford to ignore it. Good pronunciation results in successful communication, thus enabling people to get a message across more effectively (Van Weeren & Theunissen, 1987). Anderson-Hsieh & Koehler (1988) reported that some American students complained that their foreign instructors' command of English was not adequate for teaching owing to their poor pronunciation. They concluded that "pronunciation is a major factor in comprehensibility" (p. 565). Molholt (1988) also notices the need to improve the communication skills of international teaching

assistants because "their pronunciation of English makes them difficult to understand" (p. 91).

The problem of foreign assistants' poor pronunciation was once described by Jones (1979) as follows:

> Many of the graduate students are foreign students, and a good number of them are employed as teaching assistants. They are not only in the foreign language departments but also in chemistry, mathematics, engineering, psychology, etc. In spite of the fact that they were admitted to the graduate program and satisfied the entrance requirement, some of them cannot be understood by their students and some have difficulty understanding the students' questions and comments. (p. 55)

Hinofotis & Bailey's study (1980) suggested that there is a threshold level of pronunciation in English that an L2 learner has to reach in order to communicate orally regardless of his or her command of grammar and vocabulary. They emphasized that "the faulty pronunciation of a nonnative speaker can severely impair the communication process" (p. 124). However, in China, "a good English learner in this system is one who can do grammatical analysis well. It is quite natural then that grammar-translation and pattern drills are highly valued in China's English classes" (Campbell & Zhao, 1993, p. 5). That's why Campbell and Zhao claim that "even the most diligent students with the most responsible teachers often cannot communicate effectively with the target population after 10 years of studying English" (p. 4).

Second language learners cannot communicate effectively without correct pronunciation. Nowadays, millions upon millions of Chinese students are learning English as the first foreign language for variety of reasons. Some want to go abroad for further study, and others want to conduct business with people of other countries. Therefore, to teach Chinese students to learn English in a reasonably short period of

time and let them function well in the international arena is definitely the task of the teachers of English in China.

The importance of English is felt throughout the world. More than half of the publications in the world are in English. According to Kachru (1990), the last four decades have been the decades of English. In his article, Kachru pointed out that "English has acquired unprecedented sociological and ideological dimensions. It is now well-recognized that in linguistic history no language has touched the lives of so many people, in so many cultures and continents, in so many functional roles, and with so much prestige, as has the English language since the 1930s" (p. 5).

In business affairs, foreign languages are badly needed for communicative purposes. Economic experts predict that knowledge of a foreign language will be among the most sought after skills for business people from the 1980s on into the twenty-first century (Dulay, Burt & Krashen, 1982). Senator Paul Simon (1980) reminded American business people that most Japanese merchants are fluent in English in the United States. That is one of the reasons why Japanese companies are so often more successful in the United States than American companies are in Japan.

Thus, a study of five American English front vowels by adult Chinese learners of English, which are similar to or totally different from certain Mandarin Chinese vowels, is definitely necessary in order to foretell the pitfalls for the Chinese students in the process of learning. The study of vowels is very important in language learning. "The very meaning of the word depends on the quality of the vowel. If you wish to understand and be understood in English, you must be able to distinguish and make the distinction among the vowel sounds with great accuracy" (Prator & Robinett, 1985, p. 13). Through the acoustic analyses of production of five American English front vowels by adult Chinese learners of English and that by native English speakers, we will be able to tell what the most difficult front vowels are for the Chinese students to

learn -- those similar to Mandarin Chinese sounds or those totally different from Mandarin Chinese Sounds.

It has long been argued that adult Chinese learners of English cannot produce the English language as authentically as the native speakers do due to the fact that Mandarin Chinese and English are two totally different languages in the world. The best time for learning a foreign language in some aspects is over. According to Molholt (1988), some Chinese still have trouble in English pronunciation even after they have been in the United States for 25 years. Scovel (1969) claims that adults "never seem able to rid themselves of a foreign accent" (p. 245). Neufeld (1980) believes that further research may show that adults are capable of producing native-like or accent-free speech in a second language.

Lado (1957) concluded that those elements that are similar to their native language will be simple for the second language learners to and those elements in the target language that are different from their native language will be difficult for second language learners. Flege (1987b) reported that dissimilar and new L1 sounds are easier for L2 learners to pronounce than those similar ones.

Up to now, there have been a lot of evidence showing that "... adult learners generally do not pronounce the phones of a second language (L2) in a perfectly native-like way, the reasons for this apparent limitation on phonetic learning ability are not well understood" (Munro, 1993, p. 39). All the above discussions lead us to try to answer the two basic questions in foreign language speech research raised by Bohn & Flege (1992): "Can adults learn foreign language sounds? And, is their success and failure to do so explicable in terms of sounds correspondences between the native language (L1) and L2?" (p. 132) By and large, people do not think that adults can produce L2 sounds authentically.

This paper attempts to address the fundamental question: Can adult Chinese learners of English pronounce the target language sounds as authentically as the native speakers do? This question is further defined by the following specific questions:

1. To what extent can adult Chinese learners of English pronounce the five front vowels of American English?

2. What is the scale of difficulty for adult Chinese learners of English in pronouncing the five American English front vowels?

3. What category of English vowels is more difficult for adult Chinese learners of English to pronounce: those that are similar to Chinese or those that are totally different?

Child-adult Differences in the Acquisition of L2 Phonology

It is generally believed that there exists a critical period in the acquisition of L2 sounds (Flege, 1987b; Lenneberg, 1967). After the critical period is over, L2 learners are not able to acquire a native-like pronunciation of L2 sounds even for those who have been exposed extensively to a second language (Flege, 1987b).

Lenneberg (1967) made observations about second language acquisition, indicating that "the incidence of 'language-learning blocks' rapidly increases after puberty" (p. 176) and that "automatic acquisition from more exposure to a given language seems to disappear after this age, and foreign languages have to be taught and learned through conscious and labored effort. Foreign accents cannot be overcome easily after puberty" (p. 176). Such a phenomenon is also called fossilization (Selinker, 1972). Brown (1987) noticed that "this phenomenon is ordinarily manifested phonologically in 'foreign accents' in the speech of many of those who have learned a second language after adolescence" (p. 186).

Major (1994) claims that it is extremely difficult for adults to acquire a second or foreign language with a native-like accent because after a certain age it is

impossible to have second language proficiency. However, he admits that "the question has hardly been settled" (p. 182). Long (1990) even suggests that acquisition of a second language native accent at the age of six may not be possible. Scovel (1988) also strongly holds that there is a critical period for the acquisition of L2 phonology; however, there is no critical period for the acquisition of other aspects of a second language, such as syntax. He puts stress on the "Conrad phenomenon," named after the Polish-born writer whose spoken English was very poor, even though his written English was excellent. In one of his own early accent recognition studies, Scovel (1969) found that native speakers could easily and accurately identify non-native speakers of English.

Asher & Garcia (1992) found that none of their 71 Cuban subjects could achieve native English pronunciation no matter what the age of the child or how long the child had lived in the United States. However, Asher & Garcia (1982) did indicate that residence length in the United States was an important factor because those who acquired a near-native pronunciation did come to the United States at a younger age or had lived here longer. They concluded that "the younger the child, the higher the probability of pronunciation fidelity. This probability was further increased the longer the child lived in the United States" (p. 10). Another important point made by Asher & Garcia (1982) was that more girls than boys had a near-native pronunciation. In their study, 80% of the boys living in the United States for 1 to 4 years had an accent and none of them had a near-native pronunciation. Comparatively, only 30% of the girls living here for the same period of time had an accent and 30% of them had near-native pronunciation.

Seliger, Krashen & Ladefoged's study (1982) shows that there is an age limitation to the degree of perfection that adult second language learners can have. They point out that their data, however, do not necessarily indicate that improvement of adult second language learners' pronunciation is impossible. Oyama (1976) claims

that "as frustrated foreign language students can attest, really nativelike pronunciation in a second language seems as rare in an adult learner as the ability to run the 4-minute mile" (p. 261). Carroll (1963) believes that younger children can acquire a more native-like accent in a second language than older learners.

Olson & Samuels (1982) object to the assumption that younger children learn to produce foreign words with a more nativelike accent than older people. They suggest that adults are superior to children in foreign language pronunciation. The observation that children acquire better second language pronunciation than adults may be due to environmental or sociological factors. In other words, children may have a closer approximation to nativelike pronunciation because they are surrounded by people with a good accent more of the time than adults are.

Snow & Hoefnagel- Höhle (1982), while acknowledging that correct pronunciation of second language sounds is difficult to acquire after the critical period, claim that young learners do not have immediate advantage in learning to pronounce foreign sounds. In the short run, older learners are much better than younger learners at pronunciation, and only after a period of about one year do younger learners begin to excel. "Younger subjects, who were initially worse, seemed to continue their period of active acquisition longer, so that they eventually surpassed the older subjects, who leveled off at a lower point" (p. 91).

Fathman (1982) suggests that preteen children are more successful in learning the phonology of a new language. Her study showed that younger nonnative children aged 6 to 10 years received considerably higher ratings on their English pronunciation. According to Ioup & Tansomboon (1987), many researchers notice that it is easier for adults to acquire L2 syntax than L2 phonology. They realize that a near-native fluency in syntax seems much more attainable for adults than a native-like pronunciation. Ioup & Tansomboon (1987) also conclude in their own study that adult

L2 learners are unable to achieve native like control of Thai tone even after years of studying the language.

The Acquisition of English Phonology by Native Mandarin Chinese Speakers

Mandarin Chinese and English have Many structural and phonological differences. It is expected that Chinese learners of English will meet numerous difficulties in the process of learning English. Chinese learners especially have experienced difficulties in pronouncing English sounds. Chang (1987) gives the following explanation for this phenomenon:

> The phonological system of Chinese is very different from that of English. Some English phonemes do not have Chinese counterparts and are hard to learn. Others resemble Chinese phonemes but are not identical to them in pronunciation, and thus cause confusion. Stress, intonation and juncture are all areas of difficulty. In general, Chinese speakers find English hard to pronounce, and have trouble learning to understand the spoken language. (pp. 224-225)

Chang (1987) also points out that Chinese learners tend to shorten the English diphthongs since Chinese diphthongs are pronounced in a relatively shorter period of time. Chinese learners confuse / iy / with / I / because there is no such distinction in Chinese. Chang observes that Chinese learners have the tendency to nasalize the English vowel / æ / which does not occur in Chinese.

According to Eckman (1987), Mandarin Chinese speakers often add a / ə / following what is the word-final consonant in the target language. For example, they will add / ə / to "tag" to produce / t ægə /.

Juffs (1990) reported that some Chinese learners had a lot of difficulty with the English phonological system. While analyzing Chinese learners' stress errors in

English pronunciation. Juffs (1990) concluded that these errors may be due considerably to the influence of L1. The author suggested that Chinese students tend to make errors in stress since tone is important in Mandarin Chinese and stress may be considered as tone. Thus, Chinese students are much more conscious of tonic syllables and pay little attention to pitch height on the word level. According to Juffs, another problematic area for Chinese students is duration. They have a tendency to extend the length of the syllable, thus making the syllable tonic.

Tinloy et al. (1988) discussed the process of learning a second language. They claimed that people use their first language to help them learn the second language and many errors they made derive from the influence of their native language. Thus, the English errors the Chinese learners made may be related to their Chinese language system since they may apply the "rules" of Mandarin Chinese to English (Tinloy et al., 1988). Chinese learners may substitute English sounds with those that are similar to Chinese ones. For example, English has a sound / θ /, as in the word "think", which does not exist in Chinese. The Chinese learners may substitute words that have / θ / with / s /. As a result, the word "something" might be pronounced as "somesing" by Chinese learners.

Tiee (1969) conducted a significant study comparing monosyllablic structure of American English and Mandarin Chinese. He pointed out that there were many similarities and differences between the two sound systems. For Example, in English there is a series of vowel sounds in which the muscles of the tongue are tense, as opposed to another series in which they are held lax, such as / i / vs. / I /. In Mandarin Chinese there is no such contrast that is phonemic. Beebe (1984) also reported that the English vowel contrast / i / vs. / I / is difficult for Chinese learners to tell apart.

Tiee (1969) related that "the-high-front-spread vowels in the two languages are different since in the English / i / the tongue is glided upwards, While in Chinese it is steady in high -front position, without any glide at all" (p. 11). In addition, Tiee

(1969) explained that there is much similarity between the low central syllabics of the two systems. Mandarin / a / is much like the English / a / in "father", but is a little farther back. He noticed that "Mandarin speakers often tend to slow down the English clustering of nonsyllabic phonemes and are apt to insert a sort of /ə / sound in between the nonsyllabics of cluster, thus making more syllables than the word should have" (p. 13). As a result, "act" / ækt / is pronounced as / ækət / by the Chinese speakers.

Tiee (1969) reported that Mandarin Chinese speakers often confuse the English syllabic phonemes / i / and / I /, and substitute one phoneme for the other. It is not difficult for the Chinese learners to distinguish the English / ə / and / a /, which are much more similar to the Chinese / e / and / a /. The most difficult sound for them to pronounce is the English / æ /, since there is no equivalent sound in Mandarin Chinese. Finally, Tiee (1969) suggested that in order to train Chinese speakers to produce English sounds correctly , a lot of exercises in minimal pairs id obviously needed.

Stockman & Pluut (1992) studied Chinese subjects' errors in English speech. They concluded that L2 syllable-initial and -final consonant errors might not be determined simply by L1/L2 positional contrasts. Stockman & Pluut admitted that their study "did not focus directly on native English speakers' performance. Studies employing a control group of native English speakers are needed to determine if Chinese and native English speakers perform alike on oral stop and nasal consonants" (p. 41).

Acoustic Studies of First and Second Languages

The acoustic study of speech sounds was very popular in the 1950s and the 1960s. Researchers had been trying to measure the quality and consonantal differences by means of a sound spectrograph. Peterson & Barney (1952) used the sound spectrograph to analyze American vowels, and their study has been very

influential in the area of acoustic studies of speech sounds. Seventy-six subjects were recruited for Peterson & Barney's study, including thirty-three men, twenty-eight women and fifteen children. The mean F1, F2, and F3 frequencies of ten American English vowels by the seventy-six speakers were obtained and analyzed. According to Peterson & Barney (1952), children's format values are the highest in frequency and men's are the lowest with women's in the middle. However, in this study, Peterson and Barney used two subjects who spoke a foreign language before learning English. Peterson & Barney (1952) concluded that the production of vowel sounds by an individual depends on his previous experience.

In 1973, Howie published his acoustical study of Mandarin Chinese vowels and tones, attempting to make some general statements about the acoustical properties of the vowels and tones in Mandarin Chinese. The recording of Mandarin Chinese words pronounced by a single subject was made for acoustical analysis and F1, F2 and F3 frequencies of six Chinese vowels were obtained. Howie (1973) concluded that "the acoustical dimensions used in producing the synthetic speech represent a general description of the acoustical properties of Mandarin vowels and tones in citation syllables" (p. 254).

In recent years, many researchers have conducted studies on the production of L2 sounds by nonnative speakers, using acoustic measurements as indicators (Fokes & Bond, 1989; Flege, 1987a, 1987b, 1987c; Munro, 1993). Flege's study (1987b) showed that adults can produce an L2 vowel authentically if it is sufficiently dissimilar to any L1 vowel and if the learners have had sufficient L2 exposure. Flege claimed that experienced native English speakers of L2 French pronounced / y / authentically, while their French / u / was English-accented. In a previous study, Flege & Hillenbrand (1984) pointed out that adult English learners of French may produce new phones in French more accurately than L2 phones (such as French / u /) which have a clear counterpart in English, thus suggesting that new L2 phones may be acquired

more rapidly than L2 phones that have a counterpart in L1. Flege and Hillenbrand also emphasized that experience may enable adults to produce L2 phones more accurately.

Flege's another study (1993) was concerned with the production and perception of the word-final English / t / and / d / contrast by Mandarin and Taiwanese (Southern Fu-jian dialect) speakers including both child learners and adult learners of ESL. He compared the performance of the native English group with that of four Taiwanese and Mandarin Chinese groups, which included a childhood L2 learner group, an inexperienced Mandarin late learner group, an inexperienced Taiwanese late learner group, and an experienced Taiwanese late learner group. The inexperienced and experienced late learner groups were classified according to length of residence in the United States. Flege (1993) found that the child-learner group that learned English as children closely resembled native English speakers in all four experiments while the adult learners of English differed from the native English speakers. He claimed that it is child learners of English who have established phonetic representations for / t / and / d / in the final position of English words. Child learners of English made vowels considerably longer before / d / and / t / just as the native English speakers did. The adult learners of English, on the other hand, produced smaller voicing effects than the native speakers.

Shen (1990) did a study on Chinese students' production of French suprasegmentals and concluded that even those Chinese who had been especially trained in pronunciation still sounded nonnative. She related that even the one who was judged most native-like had interference from his or her mother tongue.

While discussing instruction in pronunciation for Chinese students of American English, Molholt (1988) mentioned the need to work on the duration of vowels. He claimed that Mandarin Chinese generally has a higher frequency range than English, and Chinese consonants have a higher frequency than American English consonants.

The Chinese learners cannot differentiate the English / I / and / i / in terms of duration. According to Molholt (1988), Chinese students also have difficulty in pronouncing English / ɛ / and / æ /.

Molholt (1988) stated that even though some Chinese sounds are similar to the English / ay /, / ey /, and / ow /, Chinese learners of English often use them in the wrong places. Molholt did not say whether these English sounds, which are similar to Chinese sounds, are easier or more difficult for Chinese learners of English, but he suggested that if Chinese students have trouble with the English / ŋ /, the teacher should tell them that it is similar to the final consonant in the word "yellow" in Chinese. Still, no evidence has been provided to indicate if similar English sounds will be easier for Chinese students to pronounce.

In spite of all this, Molholt (1988) did a practical and important action research on teaching English pronunciation for Chinese students. By using a computer and a speech Spectrographic Display (SSD), Molholt (1988) showed Chinese students the acoustical information about the location, extent, type, and significance of the error with the help of a native speaker's model.

Instrumentation

The human voice is an instance of the phenomenon of sound. Sound waves may be analyzed in terms of time as well as in terms of space (Ogilvie & Rees, 1969). The frequency and time people use in pronouncing sounds can make a difference. That is to say, formant frequencies and vowel durations are two important elements to be measured in acoustic studies. Some scholars have even indicated that the first two formant frequencies are very informative and usually are the ones to be analyzed for vowel identification (Delattre, Liberman, Cooper and Gersman, 1952). "It is the formant pattern (especially the disposition of the first two formants) that enable us to

differentiate vowels, or to recognize repetitions of a vowel as being the 'same', even produced by different speakers" (Crystal, 1987, p. 135).

In this study, a C-program, a MATLAB with Signal Processing Tool Box, a Soundblaster Card and a PENTIUM 486 DX-90MHz computer were used to examine the acoustic measurements of F1 and F2 frequencies. The C-program was employed to digitize the speech signal with the help of a Signal Processing Box. The Soundblaster Card was put in the computer's hard drive, thus enabling the computer to make an acoustic analysis of the complex sounds and present its various components in the form of waves. The recordings were done using a Sony CFS-1035 cassette recorder.

Selection of the Subjects

This study was conducted at Texas A&M University-Kingsville. There were 16 Chinese subjects (8 males, 8 females) and 16 American subjects (8 males, 8 females). The average age of the Chinese subjects was 32, and that of the American subjects 27. The Chinese subjects were mainly students of Texas A&M University-Kingsville and their spouses. Two were graduates of Texas A&M University at College Station.

The Chinese subjects participated in the experiments as volunteers. The researcher had been keeping in touch with the Chinese subjects constantly before the experiments were conducted. Seven of them spoke a Chinese dialect (Shanghai or Cantonese) in addition to Mandarin Chinese. They all had at least a bachelor's degree and had been studying English for years: from 6 to 20 years. The length of their residence in the United States also varied from 4 months to 6 years.

The native English subjects were all students of Texas A&M University-Kingsville and participated in the experiments as volunteers. Most of the American subjects were from South Texas. One was from Vermont and had only been in Texas for four months. Among the American subjects one could speak Spanish fluently and another could speak French.

Procedures

A pilot study was conducted by recruiting some American students as subjects who were in Spanish 101 class at the time of the study. Its purpose was to see if the acoustic values of these American students were similar to those values of other American subjects obtained in previous studies by other researchers. Most American subjects in this study were students who were studying in the library of Texas A&M University-Kingsville. They were asked to pronounce some English sounds as volunteers and were glad to do so. Of course, the subjects were aware that they were subjects in a research project. The Chinese subjects had been contacted and informed of the experiments before they produced these English sounds in the library of the University. Two recordings were made at the subjects' home. Both the native English subjects and the Chinese subjects produced five English words (beat, bit, bait, bet and bat) in the carrier sentence "I say _____now." The vowels of focus in the five English words were / iy, I, ey, ɛ, æ /. The carrier sentence was employed to provide the same phonetic environments for the vowels.

Two pairs of English vowels (/iy / and / I /; /ɛ / and / æ/) produced by both the Chinese group were compared to see if the Chinese subjects differentiate between / iy / and / I / and between / ɛ / and / æ /. Subjects were seated about 8 inches from the microphone in a study room of the library at the University. The subject was provided with a list of sentences and was told to read them aloud. The subject was also told to pause before reading the next sentence. As he or she was reading, the researcher held a copy of the same list of sentences and monitored the subjects' readings of these sentences. Readings were made on a Sony CFS-1035 cassette recorder with a frequency response of 100 Hz to 10,000 Hz. The researcher would ask the subject to repeat a sentence when the production was unclear.

Acoustic Measurements and Analyses

The recorded speech sounds were transferred into the computer's hard drive as well as stored on disks for later use. The recorded sounds were digitized at 11 KHz with 8-bit amplitude resolution. The frequencies of F1 and F2 were obtained by segmenting the vowel sound from the test word into several frames and by getting the average values of these frames. In case there was only one pair of reasonable values appearing on the computer screen, these values were treated as the center frequencies of F1 and F2.

One of the objectives of this study was to be able to analyze the vowels acoustically. In order to make sure that the C-program was reliable in digitizing these vowels, three native English speakers' F1 and F2 frequencies of the vowel / iy / were digitized using both the C-program and the MATLAB program, the values obtained were the same. This indicates that the C-program we employed in digitizing F1 and F2 frequencies of the vowels was reliable. To further test the reliability of the data, the researcher compared the F1 and F2 values obtained in this study with those obtained Peterson & Barney (1952) and with those obtained by Munro (1993). The results are quite similar.

Research Design and Statistical Analysis

The main purpose of this study was to determine whether adult Mandarin Chinese learners of English can pronounce the five American English front vowels and diphthong / iy /, / I /, / ey /, / ɛ / and / æ / as authentically as native English speakers do and to find out the scale of difficulty in pronouncing these American English vowels by both male and female adult Mandarin Chinese speakers. The mean F1 and F2 frequencies of / iy /, / I /, / ey /, / ɛ / and / æ / produced by both adult Mandarin Chinese speakers and native English speakers were compared and analyzed. Secondly, paired comparisons of / iy / and / I /, / ɛ / and / æ / were also conducted to

see if adult Chinese learners of English differentiate between / iy / and / I / and between / ɛ / and / æ / acoustically.

To be exact, the following comparisons are to be carried out in this study:

1) Acoustic comparison of five American English front vowels and diphthong (/iy/, / I /, / ey /, / ɛ /, / æ /) produced both by native English speakers and by adult Mandarin Chinese speakers.

2) Acoustic comparison of English / iy / and / I / produced by adult Mandarin Chinese speakers.

3) Acoustic comparison of English / ɛ / and / æ / produced by adult Mandarin Chinese speakers.

There are different ways of classifying American English front and back vowels. In this study, the researcher is adopting Prator & Robinett's classification (1985) because the transcription is helpful for foreign learners of English (Ladefoged, 1975). Since the production of vowels by male and female subjects can be quite different as indicated by Peterson and Barney (1952), the production of vowels by male and female subjects will be compared separately in this study. The five American English front vowels are produced in / bVt / context.

The F1 and F2 frequencies of the American English front vowels and diphthong / iy /, / I /, / ey /, / ɛ / and / æ / produced by both native English speakers and adult Mandarin Chinese speakers were compared through a two-tailed t-test (Crowl, 1993). A matched t-test (Hatch & Farhady, 1982) was employed to compare the difference between the English /iy / and / I / and the difference between the English / ɛ / and / æ / produced by the Chinese group.

By carrying out the t-tests, the researcher was able to find out the acoustic differences in the production of the five English vowels and diphthong by the two groups at different levels of significance (p .05; p .01; p .001).

Analysis of Data: Chinese Male Phonology

It is interesting that the mean F1 frequencies of both /iy / and / I / produced by adult Mandarin Chinese male speakers are significantly different from those produced by native English male speakers. The English / iy / and / I / are said to be similar to the Chinese / i / but different from the Chinese / i / (Deng, 1987). The English / iy / is more similar to the Chinese / i / than is the English / I /. In detailed analysis, the English / iy / and / I / are quite different from the Chinese / i /: a) the position of the tongue is higher while pronouncing the Chinese / i / than the English / iy / and / I /; b) there is friction while pronouncing the Chinese / i / (Deng, 1987), whereas there is no such friction while pronouncing the English / iy / and / I /; and c) even though the English / I / sounds similar to the Chinese /i /, they are far from the same. However, as Deng (1987) pointed out, the Chinese learners of English have a tendency to pronounce the English / I / as the Chinese / i /. In this study, it was found that the English vowel that sounds similar to the Chinese vowel but actually quite different from it is more difficult for adult Chinese learners of English to pronounce accurately.

Evidence of this study shows that there was no statistically significant difference between the mean F1 and F2 frequencies of the American English / ey / pronounced by native English male speakers and those pronounced by adult Mandarin Chinese male speakers. Actually, the English / ey / is so similar to the Chinese / ei / that it is "almost identical" to the Chinese / ei /. If you open your mouth a little too wide while pronouncing the English / ey /, you are likely to produce the Chinese / ei / (Bao, 1987). There is no trouble at all for Mandarin Chinese male speakers to pronounce the English / ey /.

Significant difference was found between the mean F1 frequency of the American English vowel / ɛ / produced by native English male speakers and that produced by adult Mandarin Chinese male speakers. The English / ɛ / is not similar to any of the Chinese vowels. The English / æ / is a totally new sound to adult Chinese

male speakers as well. However, the difference between the production of the English group and that of the Chinese group failed to reach the statistically significant level.

Unlike native English male speakers who made a great distinction between the production of / iy / and that of / I / in terms of both F1 and F2 frequencies, adult Mandarin Chinese male speakers failed to make any significant difference at any of the three levels ($p < .05$; $p < .01$; $p < .001$) between the production of / iy / and that of / I / in terms of F1 and F2 frequencies. Orion (1988) once stated that "many students of English as a second language do not hear the difference between / iy / as in 'see', and / I / as in 'sit' " (p. 56). This study shows that the Chinese male subjects do not make any significant distinction between the two vowels while producing the output, let alone while receiving the input.

Like native English male subjects, Chinese male subjects also made significant distinction between the production of / ɛ / and that of / æ / in terms of F1 frequencies. However, the t-value of the native group would be much higher than that of the Chinese group, thus indicating that the distinction between the two vowels made by native English male speakers was at a significantly higher level.

Analysis of Data: Chinese Female Phonology

By and large, the production of the five American English front vowels by adult Mandarin female speakers is similar to that by adult Mandarin Chinese male speakers. But they performed better than the Chinese male group. Unlike Chinese male speakers whose mean F1 frequency of / iy / was statistically significantly different from that produced by native English male speakers, Chinese female subjects' F1 and F2 frequencies of / iy / were not statistically and significantly different from those produced by native English female speakers. Especially in terms of F1 frequency of the vowel / iy /, Chinese female group and native English female group's productions were extraordinarily similar. Chinese male subjects had trouble pronouncing the vowel

/ I /, as did Chinese female subjects whose mean F2 frequency of the English / I / was significantly different from that of native English female subjects. This evidence indicates that the English / I / is hard for adult Mandarin Chinese speakers both male and female to pronounce.

In this study, the English / ey / did not pose a problem for Mandarin Chinese male speakers and neither did it pose a problem for Mandarin Chinese female speakers. The English / ey / is so similar to the Mandarin Chinese / ei / as to be almost identical to its Chinese counterpart. That is the reason why both Chinese male and female speakers had no difficulty pronouncing the American English / ey /.

It was found that both Chinese male group and female group's mean F1 frequencies of the English / ɛ / were significantly different from those of native English male and female groups'. Once again this shows that / ɛ / is another English vowel that is hard for adult Chinese learners of English to pronounce. As for the English / æ/ which is totally new to adult Mandarin Chinese speakers, the differences between the mean F1 and F2 frequencies of native English female group and those of Chinese female group failed to reach significant level.

Like the Chinese male group, Chinese female group failed to make any significant distinction between the production of / iy / and that of / I / in terms of F1 and F2 frequencies, whereas the native English female group made a significant distinction between the two English vowels. The difference between the production of / ɛ / and that of / æ / in terms of F1 and F2 frequencies made by both native and nonnative female groups were similar. It is obvious that native female group's t-value of F1 frequency would reach the level of significance. Evidence shows that the Chinese female group had a tendency to make a distinction between / ɛ / and / æ /, since their t-values of F1 frequencies nearly reached the significant level.

Conclusion

The first research question asked to what extent adult Chinese learners of English could pronounce the five American English front vowels. The results of this study indicate that adult Mandarin Chinese male speakers were quite successful in producing native-like F1 and F2 frequencies for the English diphthong / ey / and the vowel / æ /, especially for / ey /, the t-values were very low (t = 0.76, t = 0.149). In the case of Chinese female group, they were quite successful in producing native-like F1 frequency of / iy /, native-like F2 frequency of / æ /, near native-like F2 frequency of / iy / and near native-like F1 frequency of / æ /. The Chinese female subjects were also successful in producing near native-like F1 and F2 frequencies of / ey /.

The second research question asked what the scale of difficulty was for adult Chinese learners of English in pronouncing the five American English front vowels. The results of this study indicate that for both Chinese male and female groups there were no statistically significant differences between the productions of / ey / and / æ / and the native productions of / ey / and / æ / in terms of F1 and F2 frequencies. The evidence shows that among the five American English front vowels / ey / and / æ / are the easiest ones for adult Mandarin Chinese speakers to pronounce.

The results of this study also indicate that for both Chinese male and female groups there were statistically significant differences between the Chinese productions of / ɛ / and the native productions of / ɛ / in terms of F1 frequencies. Both Chinese male and female groups produced higher mean F1 frequencies than the American subjects did. The Chinese subjects also pronounced / I / with F1 (for the male group) and F2 (for the female group) values significantly different from the native ones. Thus, the evidence shows that out of the five American English front vowels / I / and / ɛ / are the most difficult ones for adult Mandarin Chinese speakers to pronounce.

The results of this study show that / iy / could be either difficult or easy for adult Mandarin Chinese speakers to pronounce. For the female group, there was no

statistically significant difference between the Chinese and the American productions of / iy / in terms of F1 and F2 frequencies. However, Chinese male subjects' data indicate that there was statistically significant difference between the mean F1 frequency of the vowel / iy / produced by adult Chinese male speakers and that produced by native English male speakers. Therefore, the researcher of this study concludes that among the five American English front vowels, / ey / and / æ / are the easiest ones for adult Mandarin Chinese speakers to pronounce; / I / and / ɛ / are the most difficult, and / iy / lies in the middle of the scale of difficulty.

The third research question asked what category of English vowels was more difficult for adult Chinese speakers to pronounce: those that are similar to Chinese vowels or those that are totally different. At this point, the author of this article concludes that (1) the English vowel / I / that sounds similar to the Chinese vowel but actually quite different is more difficult for adult Mandarin Chinese speakers to pronounce; (2) the English / ey / that is almost identical to the Chinese counterpart is easy for adult Mandarin Chinese speakers to pronounce; (3) those English vowels such as / ɛ / and / æ / that are totally different from any of the Chinese vowels may or may not be difficult for adult Mandarin Chinese speakers to pronounce.

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